7.0 Principles of Application

■ 7.1 Introduction

The purpose of this chapter is to give additional guidance on the application of the methods presented in this manual. Based on case study applications, advice is provided on determining which methods are most applicable in common planning problems. Case studies in three cities (Lawrence, Kansas; Appleton-Neenah (Fox Cities), Wisconsin; and Green Bay, Wisconsin) are presented in detail in Chapters 8 and 9. The intent of the case studies is to describe the full scope of an urban freight forecasting effort, to illustrate the best use of available data and resources, and to show where professional judgment can be exercised to expedite the work and enhance the quality of the results.

In order that the methods of this manual can be better illustrated, the case study cities were selected to be smaller urban areas. Nonetheless, the general principles of application, as described in this chapter, would apply to much larger cities. The case study cities have one other important common feature -- they are located in States that have recently created a statewide freight forecast with methods compatible to those of this manual. Thus, Chapter 8 describes the advantages and disadvantages of trying to interface the statewide and regional levels of forecasts.

7.1.1 Sizing the Effort

The earlier chapters in this manual contain numerous valuable suggestions for data collection and conducting a quick response freight forecast, but not all of the suggestions are worthwhile in any given area. When applying the methods of this manual, it is important to understand:

- the nature of the freight system in the area;
- the desired uses of the forecast;
- the availability and quality of data; and
- the needed accuracy, taking into consideration how the freight forecast relates to passenger forecasts.

Often, freight is only a small part of a larger forecast encompassing both passenger and truck travel. In these instances, the goals of the whole forecast need to be considered. The level of effort expended on the freight forecast should be proportionate to its importance in the whole forecast and to its potential contribution to the accuracy of the whole forecast. For example, if trucks comprise only 10% of the traffic in the area, then it would seem unreasonable to spend 50% of the forecasting effort on the freight portion. The challenge is to produce quality results by being resourceful, while still being efficient.

Using Error Theory to Guide the Size of Effort. Doing a brief error analysis is another way of judging the adequacy of the amount of effort. Error theory states that the most unreliable inputs have the greatest impact on the quality of the outputs. Consider the following example. Average volumes on major arterials in a city are 20,000 vehicles per day, with trucks constituting 10% of the traffic. Assume the root mean square error (RMSE) of assigned passenger car volumes to be 2,700 vehicles (about 15% = 2,700/[0.9*20,000]). Now compare the effect on total error of a 15% RMS error in truck volumes with a 30% RMS error, making the typical assumption that errors are independently distributed random variables.

$$\text{Total Error from a 15\% Truck Error} = (2{,}700^2 + 270^2)^{1/2} = 2{,}713$$

$$\text{Total Error from a 30\% Truck Error} = (2{,}700^2 + 540^2)^{1/2} = 2{,}753$$

The truck forecast can tolerate a much greater error than the passenger car forecast without adversely affecting the total vehicle forecast. Of course, this conclusion does not apply to instances where the freight forecast is of primary importance.

■ 7.2 Major Steps of Application

Once the goals and priorities have been established, a freight forecast would involve the following five steps:

1. Obtain Network and Employment Data
2. Obtain Calibration Data
3. Prepare Base-Year Forecast
4. Forecast Employment and External Station Data
5. Integrate the Freight and Passenger Forecasts

In the three case studies Step 3, preparing the base-year[1] forecast, took the largest amount of time. Step 3 would likely take the longest in most other cities, too. The base-year forecast is where all decisions on model structure are finalized, where most assumptions relating to data preparation are made, and where all parameters are locked in place. In

[1] A "base-year forecast" is not truly a forecast, as a large amount of information about the base-year is already known. Planners frequently perform base-year forecasts to calibrate and validate their networks and parameters. The steps in conducting a base-year forecast are the same as a future-year forecast.

addition, a good base-year forecast allows an assessment of the overall accuracy of the forecasts. Chapter 9 devotes a considerable amount of space to the issue of building a good base-year forecast.

Another time consuming step is employment data preparation. Reasonably good data can be adapted from the passenger forecast, but such data require substantial conversion and enhancement. The original industrial categorization of employment data may be inappropriate, as may be the selected set of special generators. Data conversion and special generator definition for the case study cities will be described later in detail.

■ 7.3 Data Stretching

A major difference between an "ideal" forecast and a "quick response" forecast is the degree of reliance on data already available. As will be seen in the case studies, data can be far from ideal. The methods in this manual permit liberal extrapolations of existing data to cover holes left by missing data items. Every forecast has a different mix of existing data, so specific rules for data stretching cannot be given. To obtain acceptable results, data stretching requires considerable amount of judgment and insight.

■ 7.4 Resolving Data Contradictions

Base-year forecasts and calibration exercises must deal with contradictions or inconsistencies in data. When assembling data from multiple sources the likelihood of major contradictions increases. In most instances it is possible to rate the quality of the sources and to use these ratings as a guide. Unfortunately, requirements for data stretching sometimes involve the joint use of two or more contradictory sets of data. Means of resolving contradictions include:

- ignoring a data item from a weaker data source;
- ignoring a data item that is inconsistent with other data from its own source;
- ignoring a data item that is illogical or that violates conventional wisdom;
- taking a weighted average of two contradictory data items;
- using data from the weaker source as advisory only, such as forming assumptions about how data from the stronger source can be stretched or reorganized; and
- using both data items, but relying on statistical measures to ensure that parameters have been adjusted properly.

Contradictions can also arise between two different forecasts of input data or between forecast data and actual data. The case studies illustrate how data from multiple sources can be used to the best advantage.

7.5 Levels of Validation

Model validation consists of comparing the results of a base-year forecast against known conditions. In general, for travel forecasting models, validation data consist mainly of link volumes and speeds. For freight forecasts, it is very helpful (though not essential) that information be available about the volumes of trucks on many highways scattered throughout the urban area.

In theory validation differs from calibration. The objective of calibration is to set the parameters of the model to obtain the best fit to reality. Thus, calibration should be performed ahead of validation. However, in practice calibration and validation are often performed at the same time with the same set of traffic count data.

There are three important levels of validation: no validation; validation of the freight forecast by itself; and joint validation of passenger and freight forecasts.

> **Level 0 - No validation.** For site impact studies and certain other forecasts where base-year data are unavailable or irrelevant, it is not possible to validate. In these instances, the methods of this manual should be trusted to produce an adequate forecast. Results should still be inspected for internal consistency and reasonableness.
>
> **Level 1 - Validation of the freight forecast by itself.** The methods of this manual permit a limited validation of the freight forecast against truck counts. A complete validation cannot be performed because it is not possible to use preferred methods of traffic assignment on trucks by themselves, without knowledge of the congestion effects of passenger cars.
>
> **Level 2 - Joint validation of passenger and freight forecasts.** Ideally, validation should include both trucks and passenger cars. The assigned traffic volumes can then be compared with known counts of passenger cars and trucks. Depending upon the selected travel forecasting software/method, it may not be possible to distinguish trucks from passenger cars in the assigned volumes. In such cases, truck traffic and passenger car traffic must be combined for comparison.

In the absence of good truck traffic counts, it is still possible to partially assess the validity of the forecast by comparing assigned volumes to approximations of the existing truck traffic on a sample of links. One way of approximating existing volumes is to factor known volumes for all vehicles by the percentages of trucks on highways of different functional classes (see Table 4.2).

7.5.1 Need for Recalibration of an Existing Forecast

When adding a new freight component to an existing passenger forecast, a complete recalibration of the whole model is essential. Because of the likelihood that the passenger vehicle model has been fudged to account for the truck traffic, this recalibration must be performed even when the freight forecast has been independently validated. The recalibration must first remove any unwanted elements in the passenger vehicle forecast before performing a *Level 2* validation on the whole forecast. One popular method of indirectly including freight into a passenger forecast had been to increase the trip generation rates for the NHB trip purpose.

7.5.2 The Need for Orderly Freight Information at Both State and Regional Levels

The preparation of a good freight forecast can be hindered when essential data are disorganized or is missing. Two sets of data are of particular concern: traffic volumes and employment.

> *Traffic Volumes.* Because it is difficult to distinguish between truck and passenger cars on automatic counting equipment, many states and cities do not regularly count truck volumes on a good sample of links. The absence of truck counts almost eliminates the possibility of an independent validation of a freight forecast. A truck counting program in support of a modeling effort should count most freeway links, most off-ramps and on-ramps, and a representative sample (10% to 25%) of major arterial links. Since the percentage of trucks in a traffic stream varies considerably throughout the day, counts should be made for a full 24 hours on enough links so that a time-of-day distribution can be ascertained for each functional class.
>
> *Employment Database.* Having an up-to-date listing of employers is important for freight forecasting. Each separate employment location should be identified by the number of employees and by TAZ. Each employer should be identified by SIC.

Management Systems. Information relevant to regionwide freight forecasting can be present in congestion management systems and in intermodal management systems that are maintained by state departments of transportation. Intermodal management systems, in particular, are discussed in Chapter 8.

■ 7.6 Issues in Using Standard Travel Forecasting Software

A freight forecast will likely be made with software originally written for passenger car forecasting. Thus, some adjustments to standard setup will be necessary. In addition, each software package has its own peculiarities that will need to be accommodated. Below are some examples.

7.6.1 Purpose Designation

This manual introduces nontraditional trip purposes that are defined primarily by vehicle class. Depending upon the software package, it may be necessary to assign each freight trip purpose to a proxy (e.g., light trucks to *Home-Based Work* or combination vehicles to *Home-Based Other*). All parameters associated with the original trip purpose should be adjusted accordingly. The *Nonhome-Based* trip purpose can also be used for a single vehicle class, but this purpose should not be the catchall for otherwise unexplained truck travel.

7.6.2 Rationalizing Production-Attraction versus Origin-Destination

The trip generation step described in this manual results in estimates of total trip ends. One may easily conclude that 50% of the trip ends are origins and the other 50% are destinations. However, some travel forecasting packages require that the results of the trip generation step be put in terms of productions and attractions. Thus, it may be necessary to split trip ends across productions and attractions rather than splitting them across origins and destinations. It is important to understand this distinction before performing the forecast and to assure that the model is correctly interpreting the trip generation information. For example, gravity models will disallow trips between two zones when both of them have only trip productions or both of them have only trip attractions.

7.6.3 Integrating Freight and Passenger Forecasts

If the modeling software has a sufficient number of trip purposes, it may be possible to perform a freight forecast at the same time as a passenger forecast. Otherwise, the freight forecast should be performed prior to the passenger forecast. The results of the freight forecast can take one of two forms: (1) truck volumes for each link that will be pre-assigned to links in the passenger forecast; or (2) a truck origin-destination trip table that can be assigned to the network at the same time as passenger car trips. Depending upon the chosen assignment method and features of the software, each form has its advantages and disadvantages.

The advantages of pre-assigning trip to links are: (1) PCE factors can be adjusted for grade and other road conditions specific to individual links (see Section 4.6); and (2) certain links and turn movements can be prohibited.

The advantages of assigning a truck trip table at the same time as a passenger car trip table are: (1) faster software execution; (2) less data manipulation; and (3) the ability to reroute trucks to avoid congested links and turns.

■ 7.7 A Quick Approach for Recategorizing Employment Data

Trip generation for freight modeling requires a fairly detailed account of the employment in a given region. Different MPO's and planning organizations have different ways of storing and presenting employment data. A typical task of freight forecasting is to recategorize existing employment data to correspond to the trip generation categories of this manual. Preferably, employment should be recategorized using original source data. However, sometimes the original data are not available or is in an inconvenient format.

The trip generation rates in Table 4.1 are used for calculating the trip ends per employee by type of industry. Rates are given for the following categories:

- office and service employment (office);
- manufacturing, transportation, communications, utilities, and wholesale trade employment (manufacturing);
- retail trade employment (retail), and;
- agriculture, mining and construction employment (other).

The case study example for Green Bay (Wisconsin) is taken to illustrate the steps in the process of recategorizing employment data.

Green Bay employment data were originally organized into three categories: commercial employment; manufacturing employment; and other employment. The SIC's within each of these categories were known. In addition, the 1990 Census provided a detailed breakdown of the Green Bay employment data by SIC codes (on Table 146, "Industry of Employed Persons: 1990").

Following is a step-by-step account of the procedure involved in the reallocation of the employment data.

Step 1. Calculate the percentage of the 1990 Census employment by category.

Table 7.1 Employment by Category in Green Bay

Industrial Sector	Persons Employed	% Employed
Agriculture	2312	2
Forest/Fishing	43	0
Mining	60	0
Construction	4790	5
Manufacturing	22405	23
Transport and Communication	7618	8
Wholesale	5065	5
Retail	20022	20
FIRE	5954	5
Services	28219	28
Public Administration	2654	3

Source: Census for the Green Bay SMSA.

Step 2. Define local and this manual's employment categories in terms of Census categories.

As seen in Table 7.1, the Green Bay employment data were split into 11 categories by SIC codes. These were reallocated into four trip generation categories, corresponding to those of Section 4.2 of this manual, using the SIC codes as a guide.

Table 7.2 Definitions of Employment Categories

Census Category	Trip Generation Category	Local Category
Retail	Retail	Commercial
Services	Office	Other (28%)
FIRE	Office	Other (5%)
Public Administration	Office	Other (3%)
Manufacturing	Manufacturing	Manufacturing
Wholesale	Manufacturing	Other (5%)
Transport/Commun	Manufacturing	Other (8)
Construction	Other	Other (5%)
Mining	Other	Other (0%)
Forest/Fishing	Other	Other (0%)
Agriculture	Other	Other (2%)

From values in Table 7.2 it is seen that 56% of all employment was originally classified as "other" by the Brown County Regional Planning Commission (Green Bay's MPO).

Step 3. Develop splits of local employment categories into trip generation categories.

A matrix of spits, relating the two sets of categories, could then be developed from the data of Tables 7.1 and 7.2.

Table 7.3 Matrix of Employment Splits

	Office	**Manufact.**	**Retail**	**Other**
Commercial	0.	0.	1.	0.
Manufact.	0.	1.	0.	0.
Other	(28+5+3)/56 = 0.643	(5 + 8)/56 = 0.232	0.	(5+2)/56 = 0.125

Each row of the table sums to 1.0.

Step 4. Apply the splits to zonal data.

First, remove special generators for the employment data for each zone and directly place the special generator employment into the appropriate trip generation category. For the remaining employment, divide them into their new categories according to the splits developed in Step 3. For example, consider TAZ #15 with 215 commercial employees, 51 manufacturing employees, and 152 other employees. The following table splits these employees across trip generation categories, then finds the total employment in each category.

Table 7.4 Application of Splits to TAZ #15

	Total	**Office**	**Manufact.**	**Retail**	**Other**
Commercial	215	0	0	215	0
Manufact.	51	0	51	0	0
Other	152	0.643*152 = 98	0.232*152 = 35	0*152 = 0	0.125*152 = 19
Total	418	98	86	215	19

This method should be avoided in zones with just a few large employers, as it may be easier and more accurate to use original-source data.

7.8 Network Options for Site Impact Analysis

Site impact assessment requires a network with a very detailed representation of the streets and intersections in close proximity to the chosen site (see Chapter 5). There are three major strategies for drawing networks for site impact analysis.

Strategy 1 - Existing Network. A good existing regionwide network is available. Incorporate the site into the existing regionwide network, in order to include the site traffic with all other traffic (trucks and passenger vehicles). This strategy differs little from traditional regionwide forecasting. All TAZ's are shown at the usual level of detail, but the site becomes one or more additional zones. It should be recognized that many sites contribute only a few trucks to streets during any single hour. Therefore, the implementation of this strategy requires very precise applications of traffic assignment, so that the true impact from this site may be differentiated from errors inherent in the traffic assignment algorithm itself, for example, convergence errors associated with insufficient equilibrium iterations.

Strategy 2 - Special Subarea Focusing Network. Create a special purpose site impact network, implementing the concept of subarea focusing. Subarea focusing involves a precise representation of the site and neighboring streets, but uses coarse representations of the road system and urban development well away from the site. Subarea focusing requires many fewer zones and many fewer links than traditional regionwide travel forecasting. Only the incremental traffic from the site can be estimated by such a network.

Strategy 3 - Incremental Site Traffic on Regionwide Network. Adapt the regionwide network by including the site, but forecast only the incremental traffic from the site. Besides adding the site to the network, the data at centroids and at external stations must be modified to eliminate any traffic not involving the site. Eliminating unwanted traffic can be readily accomplished by allowing only trip productions at the site and allowing only trip attractions at off-site zones and external stations. This method is illustrated by the Services Plus case study in Chapter 9.

When a regionwide network is already available, strategies 1 and 3 are most efficient. Strategy 2, subarea focusing, is preferred when a regionwide network is not available.

Time Period for a Network. Each site impact network is specific to a period of time, (e.g., a morning peak hour or a full 24-hour period). The time period is considered in two ways. First, the network's time period should be known so that the correct number of trip ends can be calculated for the site. Second, the impedances on links and at nodes should properly reflect the amount of traffic during the time period and the imposition of any time-dependent restrictions on truck movements. The means of identifying the time period depend upon the chosen software package.